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BOTANY AS A FACTOR IN EDUCATION.

THE topic is limited to secondary education, and falls naturally under two heads: (1) the special function of botany in secondary education; and (2) the general function of botany as a representative scientific study.

I. THE SPECIAL FUNCTION OF BOTANY IN SECONDARY EDUCATION.

The day has long passed when any argument is necessary to show that botany should have a place in secondary education. Its full importance is doubtless not appreciated by all constructors of school programs, or even by all students of education, but its place has been made secure. It is my purpose to present some of the reasons for the presence of botany in secondary schools, and these will indicate some of its special functions in a scheme of elementary education. Perhaps no science has suffered so much in public estimation from its history, for the idea that it is a "beautiful" subject, appealing to the æsthetic and the sentimental nature, rather than a serious subject full of hard work, seems to be firmly riveted in the minds of the generally informed. It is my judgment that the next generation, the one that is studying botany now, will largely correct this impression. My first reason for the presence of botany in secondary schools is—

1. *Plants enter very largely into human experience.*—This touches upon one of the fundamentals of elementary education; for it is certainly fundamental that such training must relate the pupil to his most common experiences. It is evident that one of the most obvious facts in this world is the vegetation that forms the natural covering of the earth's surface. One might almost as well omit any considera-

tion of air and of water and of sunlight as to omit any consideration of plants. Aside from the mere fact of the universal presence of plants, which thrusts them upon experience everywhere, one must also consider their enormous importance to human welfare to appreciate fully that they cannot be neglected.

2. *Plants reveal the fundamental laws of life.*—No science seems more worthy the study of man than biology, which seeks to explain his own physical life, and which introduces him to the subtlest processes of nature. It is evident now that the laws of life are the same for all organisms, whether they are plants, or ordinary animals, or man. Botany, therefore, is a biological science, and is to be so taught. Plants and animals are simply different illustrations of the same underlying principles; and, so far as biology is concerned, it is a secondary consideration which illustrations shall be used. All of the ordinary life-processes are common to both plants and animals, but for elementary instruction in biological principles plants have the advantage in at least four respects: (*a*) they are more available; (*b*) they are easier and pleasanter to handle; (*c*) they exhibit simpler illustrations of biological phenomena; (*d*) they add a life-process that is peculiar to them and of the utmost importance to the organic world, namely, the manufacture of food from inorganic material.

To get some fundamental conceptions of the life-processes into elementary education appeals to me as of the utmost importance. The utter vacuity of knowledge in regard to such matters shown by the average intelligent adult of today, leading to all sorts of crudities of speech and behavior, and even to astounding credulity in matters of serious belief, has brought me to the conviction that more science and less literature in secondary education would provide us with better-balanced adults.

3. *Plants are favorable for biological experiment.*—It must be understood that the fundamental biological conceptions cannot be obtained from the dissection of dead plants and animals alone, but must also be obtained—some would say, chiefly obtained—from experiments with living forms, such experiments as would be impossible in secondary schools with living animals. The application of stimuli of various kinds, and the responses; mistreatment in nutrition and the results; mutilation and regeneration; etc., etc., deal with fundamental con-

ceptions, to develop which only plants can be used in elementary training.

4. *Plants alone can give what are known in biology as mass-phenomena.*—Organisms not only lead their individual lives, but hold definite relations to one another and to their physical surroundings. For example, plants are not scattered at random over the surface of the earth, but are definitely organized into those communities known as associations. This large problem of mass adjustment can be displayed to the elementary student only by plants, and when his eyes are opened to it, every landscape becomes full of significance. This does not mean that the problems are easy of solution, but that they are recognized as problems full of suggestions, the chief result of which is some little conception of the larger phenomena of life.

5. *Conclusions.*—It must not be supposed that all of these things are gotten out of botany as taught in the secondary schools. The only claim is that all of these things are among the opportunities that botany offers. They will be taken advantage of according to the training and notions of the teacher. It might as well be understood in the outset that the subject of botany is so many-sided that no two competent teachers may approach it in exactly the same way. The important principles to be developed are common to all successful teachers, but the ways of getting at them are exceedingly various. It is worse than useless to attempt to make for the secondary school a course of botany uniform in all of its details. No thoroughly good teacher will approve of it throughout unless he has happened to make it himself; and this is right, for otherwise he would not be a thoroughly good teacher. It would be just as sane to attempt to have a uniform sermon preached in every pulpit of the land each Sunday morning. The only uniformity that could be secured in such a case would be a uniform subject, leaving each preacher absolutely free as to the method of its presentation. Botany is in exactly the same position in the secondary schools. We have the uniform subject, and the details of its presentation must be left to the teachers, to be determined by training and local conditions.

So far as I can see, only two things can be done or seem desirable: (1) the more competent teachers can continue writing books expressing their notions of presenting the subject, such books to be construed

merely as suggestions and advice to those who do not feel quite so competent; and (2) the universities can determine in a general way the amount and kind of contact with plants they will accept among their entrance requirements, leaving to the teacher the problem of methods and details. The independence and initiative of the individual teacher is a far more important principle to foster than uniformity even in college-entrance requirements.

I would not presume to dictate to any school the way in which botany must be taught; but I would count it a privilege, upon being made acquainted with the preparation of the teacher and the facilities at command, to suggest certain lines of work, from which as a rational being, knowing the conditions better than anyone else, he could make his choice. I would regard it as my chief function to guard inexperience against waste of time and energy, rather than specifically to direct. That school or that teacher which is held in the dictatorial grasp of some higher authority, which permits no expression of individualism in methods, which sternly represses all spontaneity and originality, which demands an automaton-like service, is pedagogically blighted.

II. THE GENERAL FUNCTION OF BOTANY AS A REPRESENTATIVE SCIENTIFIC STUDY.

There is a larger question involved than the specific contribution of botany to education, and that is the contribution of science in general. A consideration of this not merely develops certain needs in our educational system, but also suggests the real purpose and method of scientific study. The subject is too vast to be considered in so brief a paper, even in its important outlines, but two statements may not be out of place in this connection.

1. *One of the contributions of science to education is the cultivation of the scientific spirit.*—This is an attitude of mind that presents many phases, but I will speak concerning the significance of only one of these, namely, the scientific spirit keeps one close to the facts. One of the hardest things in my teaching experience has been to check the tendency of many students to use one fact as a starting-point for a flight of fancy that is simply prodigious. Such a tendency is corrected, of course, when facts accumulate somewhat, and flight in one direction is checked by a pull in some other direction. But

most of us have the tendency, and the majority are so unhampered by facts that flight is free. This exercise is beautiful and invigorating if it is recognized to be just what it is—a flight of fancy; but if it results in a system of belief, it is a deception. There seems to be abroad a notion that one may start with a single well-attested fact and by some logical machinery construct an elaborate system and reach an authentic conclusion, much as the world imagined for more than a century that Cuvier could do if a single bone were furnished him. The result is bad, even though the fact have an unclouded title. But it too often has happened that great superstructures have been reared upon a fact that is claimed rather than demonstrated.

We are not called upon to construct a theory of the universe even upon every well-attested fact, and the sooner this is learned the more time will be saved and the more functional will the observing powers remain. Facts are like stepping-stones; so long as one can get a reasonably close series of them he can make some progress in a given direction, but when he steps beyond them he flounders. As one travels away from a fact, its significance in any conclusion becomes more and more attenuated, until presently the vanishing-point is reached, like the rays of light from a candle. A fact is really only influential in its own immediate vicinity; but the whole structure of many a system lies in the region beyond the vanishing-point.

We must wonder what lies beyond, we must try our wings in an excursion now and then, but very much stress must never be laid upon the value of the results thus obtained.

Such "vain imaginings" are delightfully seductive to many people, whose life and conduct are even shaped by them. I have been amazed at the large development of this phase of emotional insanity, commonly masquerading under the name of "subtle thinking." Perhaps the name is expressive enough, if it means thinking without any material for thought. And is not this one great danger of our educational system, when special stress is laid upon training? There is danger of setting to work a mental machine without giving it suitable material upon which it may operate, and it reacts upon itself, resulting in a sort of mental chaos. An active mind turned in upon itself, without any valuable objective material, can certainly never reach any very reliable results.

It may not be that laboratory science in education is the only agency, apart from common-sense, which is correcting this tendency; but it certainly teaches most impressively by object-lessons which are concrete, and hence easiest to grasp, that it is dangerous to stray away very far from the facts, and that the farther one strays away, the more dangerous it becomes, and almost inevitably leads to self-deception.

2. *Science gives a training peculiar to itself, and one that is essential in every well-balanced education.*—The real educational significance of the training in laboratories devoted to science is very commonly overlooked, both by those who know nothing about it from personal experience, and even by those who are teachers of science. Many learn to go through the motions without appreciating the substratum of educational philosophy. Moreover, the knowledge of the educational significance of this special form of training has been slowly developed as the results have appeared.

Perhaps the earliest, and of course the most superficial, form of statement explaining the purpose of scientific study was that it teaches the laboratory method. The inference was that the sciences are of no particular educational advantage in themselves, but are merely useful in teaching a valuable method. In so far as this emphasized the fact that reading or reciting *about* science cannot be regarded as training *in* science, and in so far as it recognized that science is to be credited with introducing a revolutionary and invaluable educational method, the statement is true enough; but to regard these purely incidental results as being in any sense the end of scientific training is far enough from the mark. The laboratory method holds no more relation to science than do algebraic symbols to algebra; they both merely represent useful machinery for getting at the real results. And further, as has been shown, if the teaching of a method is the only function of science in education, when this method has been learned and has become universally applied, the special mission of science in education is at an end.

Another commonly stated advantage of training in science is that it cultivates the power and habit of observation. This is certainly true, but with equal certainty this result is not peculiar to scientific training, for it belongs to the laboratory method, and appears when-

ever the method is applied to any subject. It may be claimed that the most direct and tangible materials for observation fall within the province of science; but this is a difference of degree rather than of kind, and therefore the result may be obtained apart from science.

Those who are accustomed to look a little beneath the surface before formulating a statement are very apt to be content with saying that the study of science trains in the power of analysis. This is certainly getting the subject upon higher ground, and suggests a result which is worthy of every effort. The power of analysis is one of immense practical importance, and the value of its cultivation will not be denied. To imagine, however, that analysis is the ultimate purpose of science is not to go very much farther than to say that its ultimate purpose is the laboratory method. The latter is the method, the former is but the first step in its application. But even this step is by no means peculiar to science, for it is the initial one in the teaching of every subject. In our search, therefore, for the peculiar benefits of science in education, we are again compelled to look further.

Beyond analysis lies synthesis, and this certainly represents the ultimate purpose of science. The results of analysis are as barren as a bank of sand until synthesis lays hold of them. It is just here that a large amount of science-teaching fails, for to many teachers the accumulation of unrelated facts seems to be the end of scientific study, and the results of the laboratory may be represented by a chaotic pile of brick rather than some definite structure dominated by an idea. Almost anyone may accumulate facts, but to relate them, to distinguish the significant and the insignificant, to recognize that they are merely external expressions of something general, belongs to the highest stretches of scientific training. May I be permitted to say, without being misunderstood, that the potent influence of the German laboratories upon American establishments has resulted in general in making our best investigators and our worst teachers? The influence is beneficent to the last degree in so far as it lays hold of a disposition to careless work and hasty generalization, and holds it down to the patient collection of facts and their very cautious collocation; but when it results in mere Gradgrind teaching, all inspiration has evaporated and the laboratory touches no more the finer mental powers than does a factory.

But even synthesis is not peculiar to science. To pass by the incidental and temporary and reach the real and permanent contribution of science to education is to discover that it lies, not in teaching the laboratory method, in developing the power of observation, in cultivating the spirit of analysis, or even in carrying one to the heights of synthesis; but in the mental attitude demanded in reaching the synthesis. In this regard the demands of science are diametrically opposed to those of the humanities, for instance, using this loose term to express the great region of literature and its allies.

The humanities have been and must continue to be a noble course of intellectual development, without which an education is certainly incomplete. It is the most ancient and best-known form of culture. and, being ancient and bound up with the intellectual development of mankind, it must necessarily continue to hold high rank. The general effect of the humanities in a scheme of education may be summed up in the single word "appreciation." They seek so to relate the student to what has been said or done by mankind that his critical sense may be developed, and that he may recognize what is best in human thought and action. To recognize what is best involves a standard of comparison. In most cases this standard is derived and conventional; in rare cases it is original and individual; in no case is it founded in the essential nature of things, in absolute truth, for it is apt to shift. In any case the student injects himself into the subject; and the amount he gets out of it is measured by the amount of himself he puts into it. It is the artistic, the æsthetic, which predominates, not the absolute. It is all comparative rather than actual. The ability to read between the lines is certainly the injection of self into the subject-matter, and the whole process may be regarded as one of *self-injection* in order to reach the power of *appreciation.*

My claim is that any education which stops with this result is an incomplete one, and that there is another mental attitude which is a necessary complement before a full-rounded education can be claimed; and that this complementary mental attitude is developed by a proper study of the sciences. If the study of nature is conducted so as to cultivate merely a sentimental appreciation of natural objects, it does not fall within the category I am considering, and can in no way be considered as a study which acts as a complement to the humanities.

It is merely more of the same thing. If the proper intellectual result of the humanities is *appreciation*, whose processes demand *self-injection*, the proper and distinctive intellectual result of the sciences is a *formula*, to obtain which there must be rigid *self-elimination*. Any injection of self into a scientific synthesis vitiates the result. The standard is not a variable, an artificial one, developed from the varying tastes of man, but absolute, founded upon eternal truth.

Two such distinct mental attitudes as self-injection and self-elimination must receive attention in education, which cannot be complete without both. They are not contradictory, but complementary, and it takes both to make the "all-round" man. The exclusive cultivation of either one must result in a lop-sided development. Persistent self-injection tends to mysticism, a confusion of ideals or even vagaries with realities, a prolific cause of all irrational beliefs. Persistent self-elimination narrows the vision to a horizon touched by the senses and clips the wings that would carry us now and then beyond the treadmill of life into a freer air and a wider outlook.

The one needs the other as a check. In their combination self-injection is held back from dangerous flights by the demand to feel something solid beneath the feet; and self-elimination is compelled to raise its eyes now and then from the ground and sweep the heavens.

In our analysis, however, we strip off the flesh and lay bare the skeleton, and are apt to lose sight of the fact that the contour is a composite result. Although the skeletons of the humanities and of the sciences may differ from each other in the fundamental way described, I cannot conceive of the resulting contour of the one as distinct from combination with the other. The self-eliminating result of science must be associated with the self-injecting result of the humanities, even though science alone be studied; and the power of appreciation developed by the humanities must always be tempered by the scientific spirit. And yet the two processes and the two results are so distinct and so complementary that any scheme of education which does not provide for the definite cultivation of these two mental attitudes, and which leaves the complementary part merely to the chances of methods of teaching and mental structure, is in constant danger of resulting in mental distortion.

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